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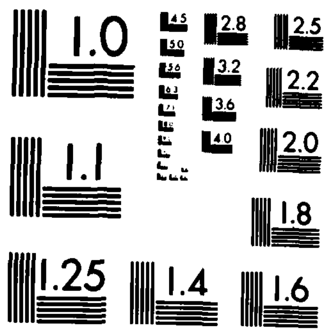

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EVALUATION OF DEFENSE MAPPING AGENCY LEVEL 1 SECOND EDITION DIGITAL DATA FOR TRAINING SIMULATOR APPLICATIONS

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1985

ABSTRACT

The Defense Mapping Agency (DMA) produces digital data bases for the DoD which are used by many systems developed for the generation of real-world simulation data. In the past, Level 1 (First Edition) Digital Landmass System (DLMS) data has been used to support visual and sensor simulation systems. This First Edition DLMS data was intended for radar simulation systems and required some enhancements by users to support these other types of simulations. Simulations of advanced systems require higher resolution data than that supplied by First Edition DLMS data.

DMA has developed Level 1 Second Edition DLMS data, and is producing this data in limited quantities over selected areas, to meet the expanding demands of the simulation community. This data contains new feature types from expanded First Edition DLMS data classifications. It provides an increase in continuity of real-world information over First Edition DLMS data. This correlates to more effective sensory queues in a simulation environment.

In conjunction with DMA, the General Electric Company has performed an evaluation of Second Edition DLMS data. It includes an examination and analysis of two Second Edition DLMS data sets produced by DMA. Corresponding First Edition DLMS data sets were supplied and used for a comparison study. A dynamic real-time visual system simulation was produced from these data sets. This paper presents the results of this evaluation, with emphasis on the dynamic visual demonstration.

INTRODUCTION

In early 1984, DMA provided GE with two Level 1 Second Edition DLMS data areas for evaluation. This Second Edition data is intended to supply improved Level 1 topographic information required for advanced simulation digital data bases (DDB's). In the past, users have found it necessary to enhance First Edition data prior to its implementation for non-radar applications. Due to the availability of First Edition data over large geographic areas, it is often designated for use in the creation of real world DDB's.

The two Second Edition data areas provided are described in Table 1. The GE evaluation includes a review of the Second Edition product specification, analysis of the data for the given areas, and a dynamic real time visual simulation system evaluation. The paper contains a summary of the GE evaluation.

DATA AREA	SIZE	AREA (SQUARE NAUTICAL MILES)
Richmond, KY	30'x30'	715
Billings, MT	1 x 1	2533

TABLE 1
SECOND EDITION DATA AREAS

BACKGROUND

Simulation training effectiveness is measured by the amount of transfer of skills required to effectively perform under real world training conditions. Early simulation training involved the elementary aspects of simulation application, such as pilot take off and landing. As simulation hardware technology advanced, new requirements were defined to allow coordinated aircrew training in a full-mission, real world environment. Weapon System Trainers (WSTs) are now available for the B-52 and C-130 aircraft, and are being developed for others. The key to the real world mission scenario capability of these systems is the source data used to create data bases to drive the visual, radar and sensor simulations. The typical WST has a data base area measured in thousands or millions of square nautical miles. Effective application of these systems lies in a reliable, cost effective data base generation technique.

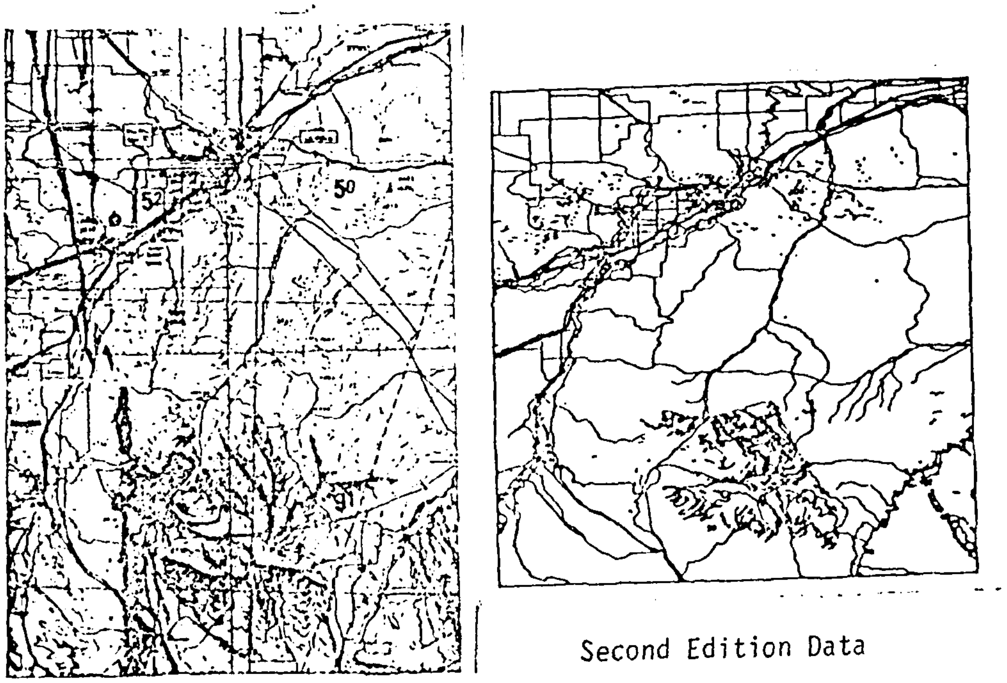
Air Force simulators in the 1970's often required an automated processing (transformation) of digital data produced by DMA to create the hardware driving data bases. The DMA Digital Landmass System (DLMS) data became the accepted source data because it is produced in a standard format over large areas of coverage. The transformation systems involved complex, algorithmic oriented procedures designed to suit the needs of a particular device and simulation.

The transformation process uses two types of DMA DLMS data. Terrain data, known as Digital Terrain Elevation Data (DTED), is given as a matrix of elevation values for the earth's surface on three arc second intervals, normally in one degree square areas. The culture data, known as Level 1 Digital Feature Analysis Data (DFAD), describes the natural and man-made features which lie on top of the terrain. It is provided in rectangular areas or manuscripts, which vary in size to one degree square maximum. Real world objects are portrayed as one of three feature types as a function of their size. Point features are used to portray discrete, regularly shaped objects which can be described in terms of length, width and height. Examples of these would be buildings, towers and domiciles. Lineal features are used to

describe items of relatively constant width, such as roads, bridges, streams, tree lines and embankments. Areal features describe the outline of an area of homogeneous content, such as a forest, lake, city or industrial complex. Information describing surface material, structure content and radar directivity are supplied for each feature.

LEVEL 1 SECOND EDITION IMPROVEMENTS

The major improvements of the upgrade to Second Edition Level 1 are the addition of line of communication data with expanded Feature Identification Code (FID) assignments. These consist primarily of roads, railroads, cleared ways, and rivers, including smaller streams. The inclusion of these features greatly improves the ability of the data base to support navigational training tasks, since they are usually used as visual confirmation check points. Figure 1 illustrates a Tactical Pilotage Chart (TPC) and the corresponding Second Edition Data plot for the Billings area.



TPC (Billings)

Second Edition Data

Figure 1

Expanded FID codes exist primarily in the Transportation Category. Specific road classifications have been added for realistic road network portrayal. Road interchange FIDs have been introduced to supply extra information along major highways. Tunnel entrance/exit features are used to explain road and railroad feature discontinuities due to the real world terrain conditions. Figure 2 compares data plots of the two data bases for the First and Second Edition areas. Table 2 lists composite feature additions for the two data areas.

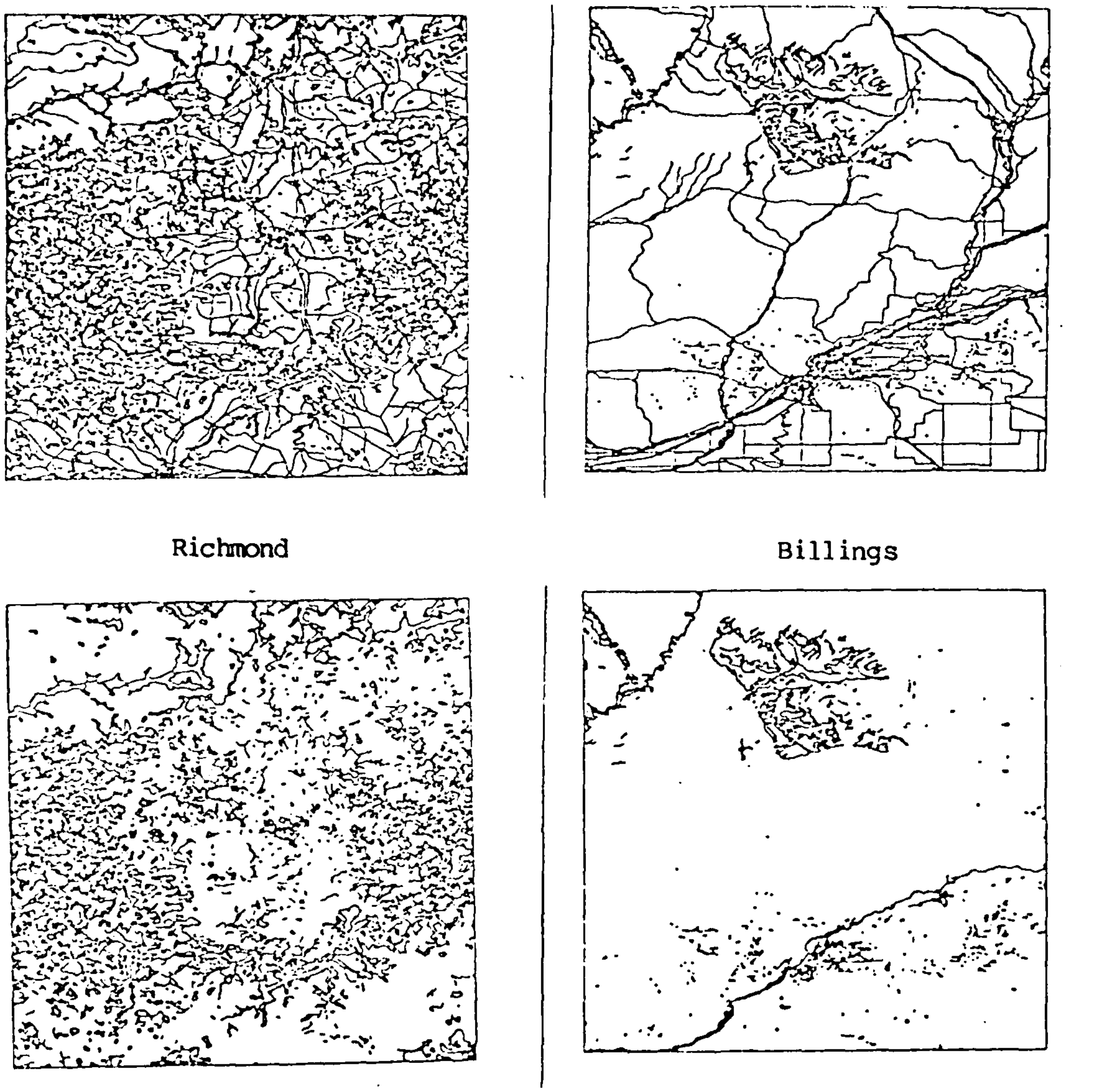


Figure 2
Second Edition Data (top)
First Edition Data (bottom)

COMPOSITE FEATURE ADDITIONS

DESCRIPTION	DMA FID CODE	FEATURES ADDED LINE	FEATURES ADDED POINT
Railroads - Mod/Hvy Activity	203	53	-
Railroads - Light Activity	204	7	-
Railroads	206	46	-
Road Interchange - Diamond	232	-	8
Road Interchange - Fork	235	-	2
Road Interchange - Trumpet	237	-	2
Road Interchange - Symmetric Ramp	238	-	2
Roads (General)	240	199	-
Dual Highway with Median	250	54	-
All Weather Hard Surface Highway	251	74	-
All Weather Light Surface Road	252	34	-
Fair Weather Light Surface Road	253	20	-
Road Under Construction	255	2	-
Bridges (General)	260	1	131
Bridges (Truss)	264	-	10
Bridge Truss Superstructure	275	2	10
Soil Ground Surface	902	-	6
Cleared Ways	916	161	-
Water Intake Towers	926	-	14
Tunnel Entrance/Exit	929	-	2
Fresh Water - Subject to Ice	943	108	-
Canal/Channel - Subject to Ice	947	14	-
Fresh Water (LOC) - Subject to Ice	949	49	-

TABLE 2

VISUAL DATA BASE PROCESSING

The C-130 Weapon System Trainer was selected for the real time visual evaluation of the Second Edition data. With the cooperation of the Military Airlift Command, the C-130 WST at Little Rock Air Force Base was made available. It has a five channel visual system built by GE, and was supplied with an automated data base transformation system. This allowed an effective, large area sample of the Second Edition data to be processed for dynamic evaluation. Corresponding First Edition data was also supplied by DMA for a comparison visual evaluation. It was used in the same manner as the Second Edition for the generation of a visual data base. This generation process is discussed below.

TRANSFORMATION PROCESSING

C-130 data base generation involves batch and interactive processing of DMA Level 1 terrain and culture data, and results in a visual data base for the C-130 visual system. The data is processed in 12x12 arc-minute blocks, and each block required approximately 1.5 hours of processing time. It operates on a Perkin-Elmer 8/32 computer system.

The batch process is controlled by a number of user defined parameters which are a function of the character of the DMA input data and the user's preference concerning the importance and fidelity of portrayal for each type of DMA feature. Most of these parameters are specified in the process control deck (actually a disc file), which influences much of transformation, including data certification, filtering or elimination of extraneous feature points, color and texture assignments for various feature types, and model library assignments for specified DMA point features.

Transformation processing is segmented into three phases: Terrain model derivation, Culture model derivation, and merging/formatting terrain and culture models. Terrain derivation involves fitting a network of triangles to approximate the earth's surface as defined by the elevation data. While many input terrain elevation posts may be eliminated, the most significant are detected and used to define the terrain triangles. The process retains those points with the greatest curvature (inflection), and uses triangle regularity versus goodness-of-fit parameters to generate a fairly regular spaced terrain network. The first criterion is intended to preserve significant peaks, valleys and ridge lines. The second is intended to distribute the scene content (density) evenly over the data base to avoid large fluctuations in the real-time hardware processing load. The relative importance of these criteria is controlled by user parameters.

Culture model derivation begins with the transfer of DMA data from input tapes to disc files, including segmentation into 12 x 12 arc-minute blocks. Since culture features frequently contain far more vertices than can be handled in a real-time simulation, a digital filter is applied to all lineal and areal features. The control parameters for this filtering are uniquely assigned for each feature type in the process control deck. The filter attempts to select the minimum number of points required to maintain the original feature shape within the control deck specified tolerance. Culture model derivation continues with another filtering process which creates three successively less detailed versions of the original features. The highest fidelity version of the culture model is used for the near scene visual simulation. The coarsest version of the culture model is used for far scene visual simulation, and usually contains only the largest source DMA features. The other culture model is used for a gradual increase in scene detail as the modeled features transition from the far scene to the near scene.

To this point, the terrain and culture models are processed separately. As these two models are merged, the terrain is used to create the underlying pattern of triangles which represent the earth's surface. The overlying culture data is then used to assign color and texture information to the terrain triangles. New surfaces are created in this process since the defined culture boundaries are not usually coincident with the terrain triangle boundaries. Once the two models are combined to form a single model, the data is ready to be formatted for input to the real-time visual system hardware.

TRANSFORMATION RESULTS

The transformation software functioned well in the Second Edition data processing. Less than 1 percent of the total number of input features were discarded due to transformation limitations imposed by the target hardware.

The corresponding Level 1 First Edition data was also processed with the transformation software. Again the software discarded less than 1 percent of the input features. Table 3 provides a comparison of the input data for the two data areas.

RICHMOND	1ST ED	FEATURE/NM	2ND ED	FEATURE/NM	% INCREASE
TOTAL FEATURES	2510	3.51	3136	4.39	25.0
POINT FEATURES	853	1.19	964	1.35	13.0
LINEAL FEATURES	998	1.40	1511	2.11	51.0
AREAL FEATURES	659	0.92	661	0.92	0.3

BILLINGS	1ST ED	FEATURE/NM	2ND ED	FEATURE/NM	% INCREASE
TOTAL FEATURES	1810	0.71	2253	0.89	24.0
POINT FEATURES	895	0.35	1042	0.41	16.0
LINEAL FEATURES	563	0.22	859	0.34	53.0
AREAL FEATURES	352	0.14	352	0.14	0.0

TABLE 3
INPUT DATA COMPARISON
FIRST EDITION VS. SECOND EDITION

REAL TIME DEMONSTRATION

The real time evaluation data bases constructed for each of two data areas were of three types: Second Edition data only, First Edition only, and hybrid First and Second Edition data. These were taken to Little Rock Air Force Base for evaluation on the C-130 WST. During this evaluation, each Second Edition data base was carefully examined. Special attention was given to the new feature types introduced in the Second Edition data and their overall contribution to the visual simulation. Flight paths were recorded while flying the Second Edition data bases and used to play back the flight with the corresponding First Edition data bases. The additional scene content of the Second Edition data proved to be sufficient for visual navigation around the data areas. The hybrid data bases were used to observe the contrast between the two data sources.

Most of the interesting features of the Second Edition data base were recorded on video tape, and a number of still photos were also taken. Figures 3a and 3b were taken from the same eyepoint in the Second and First Edition data bases, respectively. They illustrate the additional visual content of the Second Edition data for the city of Billings. Figure 4 illustrates the Diamond Road Interchange features as applied to the C-130 visual system. The simple, blocky appearance of buildings is a function of the C-130 model library, and could be improved by devoting more capacity to create more detailed models.

CONCLUSIONS

The Second Edition data far exceeds the content of the First Edition data in many respects. It includes features which previously had to be added to the First Edition data via an intensive, large area manual enhancement. The most significant improvement is the addition of Lines of Communication data. The added road and railroad features now allow visual cross-country navigation to be effectively performed in data bases generated from this data. In areas of sparse population densities such as the Billings vicinity, the addition of smaller stream category features add navigational queues as well as increased scene content in the visual simulation. Powerline and road cleared ways allow greater simulation realism by delineating these features from the underlying ground coverage. This is very effective when applied to underlying forest and vegetation features. Road interchange features add continuity and detail along major highway features, and in the future may prove to be a valuable source of information.

Overall, the Level 1 Second Edition data is a major improvement over the First Edition data. It supplies a solid base for the creation of real world simulation scenes.

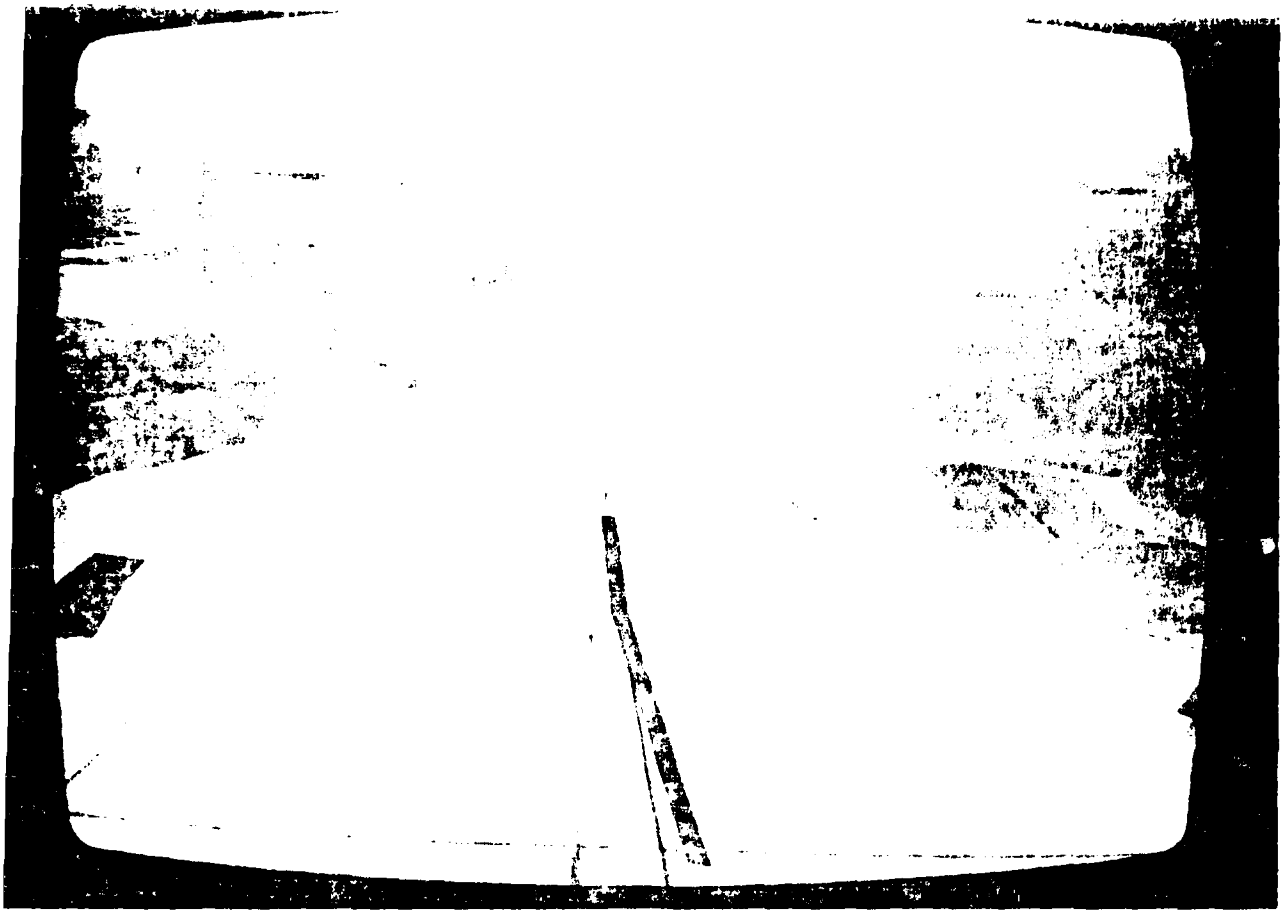


Figure 3a

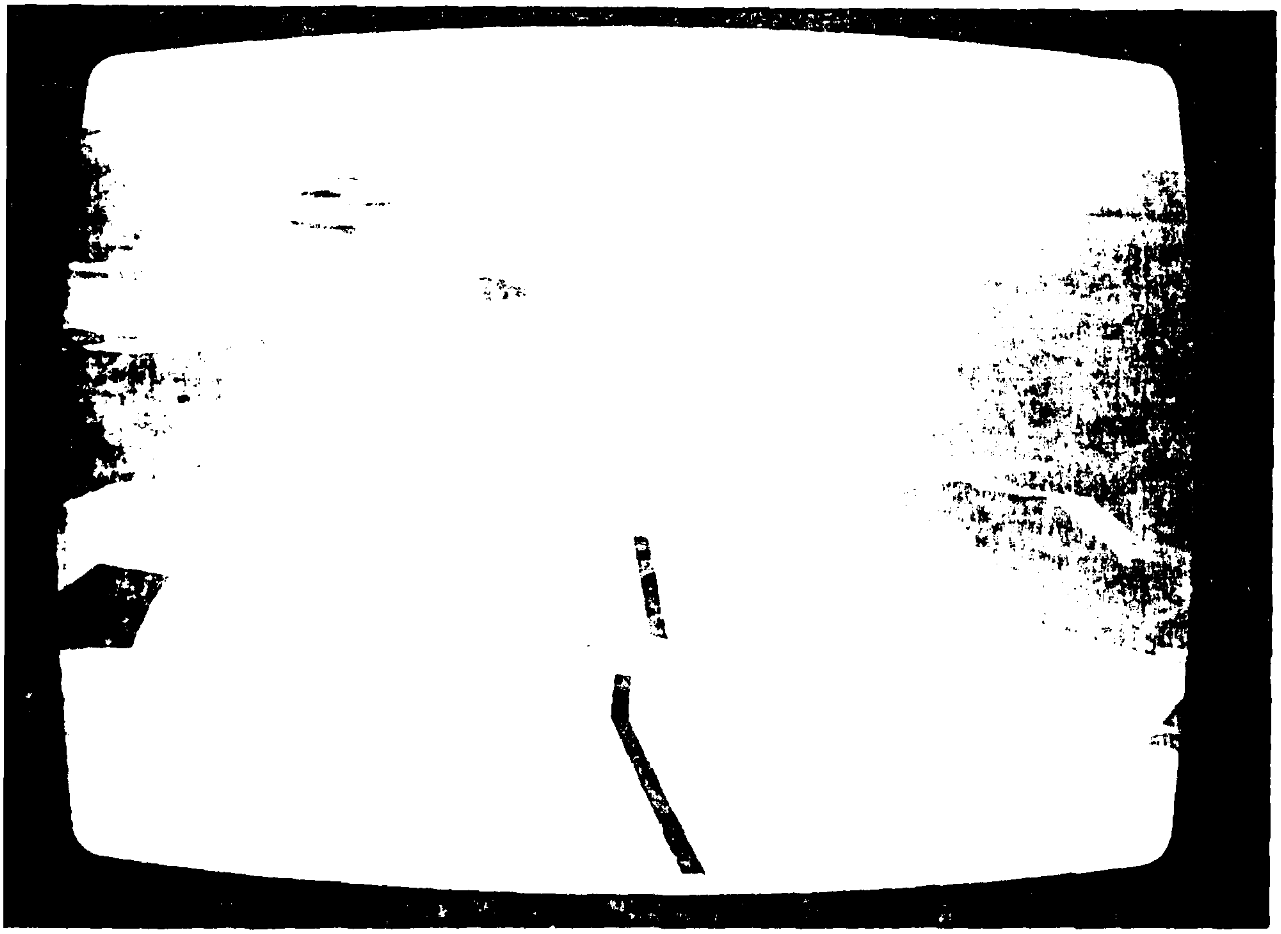


Figure 3b

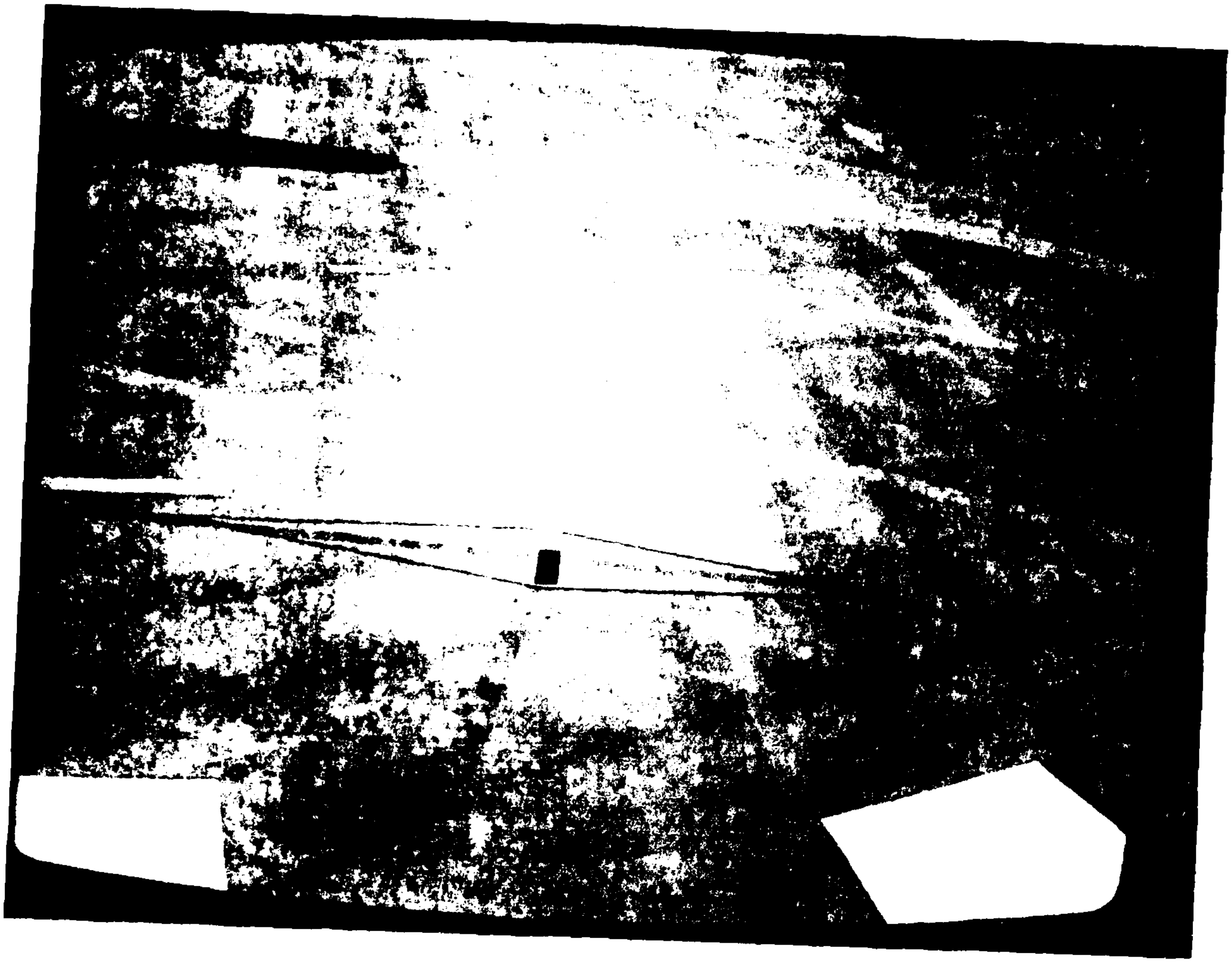


Figure 4

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